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Research Paper

Noise Level Mapping In the Work Area of Pt. Spm Ii Lampung by Comparisoning Ordinary Kriging and Inverse Distance Weight

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ABSTRACT: *The production process at PT. Sinar Pematang Mulia II Lampung involves engine power which has the potential to cause high noise. There are still workers in the production area who have not worn ear plugs or ear muffs. This study aims to compare the ordinary kriging and inverse distance weight IIDW) interpolation methods, create a noise distribution map using the best interpolation method and administrative and technical noise level control solutions. The results of both methods were evaluated based on Root Mean Square Error (RMSE) and correlation to get the best model. It has been obtained RMSE 0,08 with a correlation of 99% for the ordinary kriging method and RMSE 1,37 x 10^{-8} with a correlation of 100% for the inverse distance weight method. Based on these results, the inverse distance weight method was used to create a noise distribution contour map. From the results of mapping the distribution of equivalent noise levels in the area of washing A, washing B, rasper, extractor, separator, centrifugal, power plant A and power plant B, the noise level has exceeded the threshold value, namely 85 dBA to 105 dBA. Control Solution by rotating the noise exposure time on a scale until the cumulative fraction is less than one. Technically, by installing an acoustic shroud on a machine with a high noise level, creating a control room in the form of a production area and requiring ear plugs with an noise reduction rate (NRR) of 30 dBA and ear muffs with an NRR of 40 dBA.*
.***KEYWORDS:*** *PT. Sinar Pematang Mulia II Lampung, Noise level, Ordinary kriging, IDW*

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I. INTRODUCTION

Noise is unwanted sound because it causes disturbance to environmental comfort and human health. Noise has an impact on humans including hearing loss, communication, psychological, work productivity and health [1]. The high level of noise received by workers continuously will cause damage to the human hearing system in the form of temporary deafness to permanent deafness [2].

The production process at PT. Sinar Pematang Mulia II Lampung involves machine power and work tools that have the potential to cause high noise, especially in the production area and power plant. There are still workers in the production area who have not used ear plugs or ear muffs. The high level of noise received by workers continuously will cause damage to the human hearing system in the form of temporary deafness to permanent deafness [2].

Noise distribution mapping needs to be made to provide information on the distribution of noise levels in the research area. The distribution model can be obtained by applying the interpolation technique. Interpolation is a process of estimating values in an area that is not measured to create a distribution of values throughout the research area.

Several studies have succeeded in comparing the ordinary kriging interpolation method with the inverse distance weight but the results are inconsistent, because the good performance or not depends on the nature of the interpolated variables [3]. Comparison of accuracy using the ordinary kriging method and the inverse distance weight method for noise distribution has not been found until now. In the 1960s, Georges Matheron developed kriging to solve problems in geo-statistics. Kriging can handle regionalized variables [4]. This method uses a semi-variogram which represents the spatial differences and values between all pairs of data samples [5]. to obtain a stable semi-variogram model this method requires a minimum of 100 observation data

[6]. Ordinary kriging is a type of kriging which assumes that the population (data collection) has a constant mean, has no trend and has no outliers [7]. The IDW method is a simple method in computational effectiveness because it does not involve matrix operations [5] and has low computational costs [8]. The results of the interpolation of this method depend on the power value [9] in [10]. The greater the power value, the interpolation results will be more similar to the closest observation data [5].

This research will be tried comparison of the ordinary kriging interpolation method with inverse distance weights for get the best interpolation method with the smallest possible error using RMSE parameters and Pearson correlation coefficient. Interpolation process using python programming with PyCharm IDE software. Method best interpolation using contour distribution in the work area of PT. Sinar Pematang Mulia II Lampung.

II. METHODS

This research was conducted from April 2021 to December 2021, at PT. SPM II Lampung. Administratively, the research location is located in Bandar Mataram District, which is shown in Figure 1. Bandar Mataram District consists of nine villages or sub-districts, with an area of 1055,28 km^2 which is located in Lampung Tengah Regency, Lampung Province, Indonesia. Geographically, Bandar Mataram Regency is bordered by:

- North side : Bordered by Tulang Bawang Regency.
- On the South : Bordered by the Districts of Bandar Surabaya, Seputih Surabaya, Rumbia, Bumi Nabung, Way Seputih, Seputih Mataram and Way Pengubuan.
- East side : Bordered by Tulang Bawang Regency.
- West side : Bordered by the District of Terusan Nunyai.

Noise data obtained from measurements using a sound level meter on the shift 1 (08.00-16.00) WIB, shift 2 (16.00-24.00) WIB and shift 3 (24.00-08.00) WIB. The data that has been obtained is calculated using the following equation.

$$Lek = 10\log\left(\sum_{i=0}^{n} fi\ 10^{li/10}\right) \quad (1)$$

Furthermore, the maximum exposure time to the noise level is calculated using the following equation.

$$T(h) = 8/\left(\frac{2(L-85)}{3}\right) \quad (2)$$

The cumulative noise fraction was calculated using the following equation.

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots + \frac{C_n}{T_n} \quad (3)$$

The distribution of noise levels is simulated in the form of contours using python programming. The inputs are coordinate data and equivalent noise level data. This study will compare two interpolation methods, namely ordinary kriging and inverse distance weight. Ordinary kriging interpolation begins with determining the experimental semi-variogram to represent the correlation value between variables which is then matched with the theoretical semi-variogram model. The theoretical semi-variogram model used for comparison in this study is spherical, exponential and Gaussian [7]. Furthermore, the spherical, exponential and gaussian models were tested using the ordinary kriging method and an evaluation of the model was carried out based on RMSE and correlation to get the best model.

The next interpolation uses the IDW method. The value of power as a parameter in this method to get accurate interpolation results. The power values used in this study were 1, 2, 3, 4 and 5 [9]. If the power value ≥ 5, then the best model is obtained. After the results of the interpolation of the two methods are obtained, an evaluation of the model is carried out to obtain the best interpolation method using RMSE and correlation. The best interpolation method is used for contouring the distribution of noise levels in the work area of PT. Sinar Pematang Mulia II Lampung. Furthermore, the results of the noise distribution contour are analyzed, if there is an area where the noise level is above 85 dBA, it provides a solution for noise control.

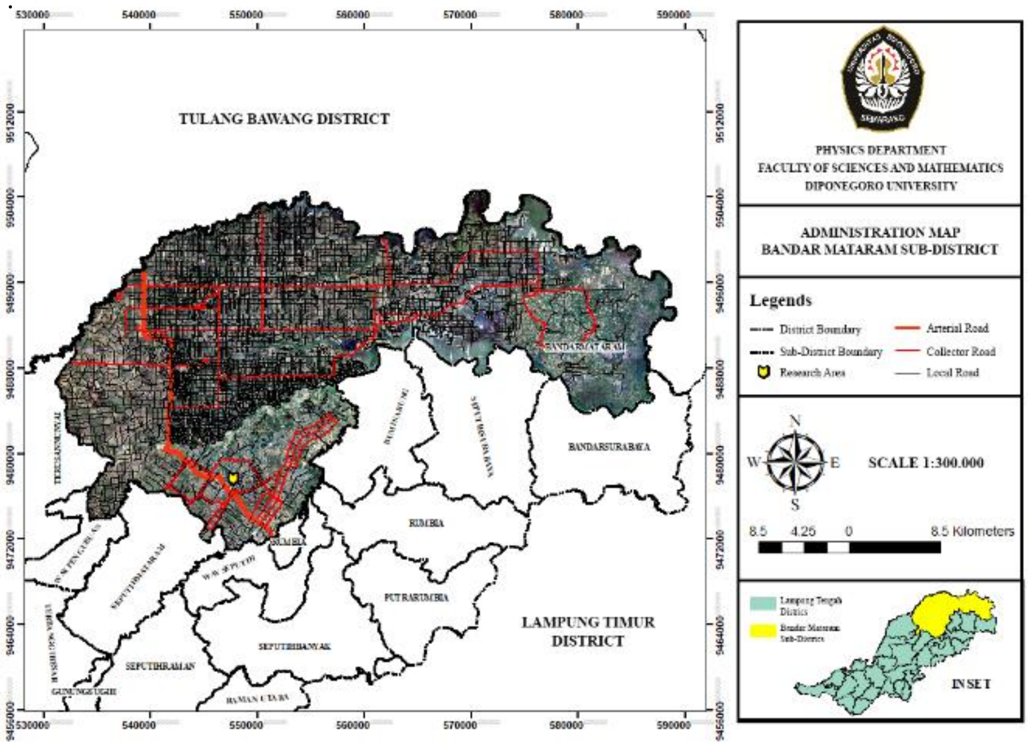

Figure 1. Research area administration map.

III. RESULTS AND DISCUSSIONS

3.1. Equivalent Noise

Measurement of noise level due to machine work is carried out in the work area of PT. Sinar Pematang Mulia II Lampung. The obtained noise data was calculated as the equivalent value for each shift using equation (1) and the average equivalent was calculated. The results of the calculation of the equivalent value are shown in Table 1.

Table 1. Noise level calculation result

Station	Noise Level (dBA)			
	Shift 1	Shift 2	Shift 3	Average
Hopper	82,5	87,5	82,5	84,85
Washing A	92,5	92,5	92,5	92,5
Washing B	92,5	92,5	92,5	92,5
Rasper	92,5	97,5	92,5	94,85
Extractor	92,5	92,5	92,5	92,5
Separator	97,5	97,5	97,5	97,5
Centrifugal	92,5	92,5	92,5	92,5
Oven A	82,5	82,5	87,5	84,85
Oven B	82,5	82,5	87,5	84,85
Bagging A	82,5	87,5	77,5	84,24
Bagging B	82,5	84	82,5	83,11
Power Plant A	102,5	102,5	102,5	102,5
Power Plant B	102,5	102,5	102,5	102,5
Coal Boiler	72,5	72,5	72,5	72,5
Diesel	75,8	75,8	72,5	74,95
Heavy Equipment	72,58	67,5	67,5	69,90
Electric	57,73	62,5	67,5	64,25
Fabrication	64,73	62,5	67,5	65,39
Office	62,92	62,27	62,53	62,57
Cassava Scales	65,95	68,61	68,47	67,84
Cassava Field	68,99	78,66	79,59	77,59

3.2 Maximum Time of Noise Exposure

Maximum exposure time noise is calculated using the equation (2). Table 2 displays the calculation results maximum noise exposure time. On when workers are exposed to high enough noise and not using personal protective equipment ear, recommended for workers only allowed to be exposed to noise at the right time maximum is determined.

Tabel 2. The result of calculating the maximum time workers are exposed to noise.

Station	Maximum time of exposure to noise (Hours)
Hopper	8,3
Washing A	1,4
Washing B	1,4
Rasper	0,8
Extractor	1,4
Separator	0,4
Centrifugal	1,4
Oven A	8,3
Oven B	8,3
Bagging A	9,5
Bagging B	12,4
Power Plant A	0,1
Power Plant B	0,1
Coal Boiler	143,7
Diesel	81,4
Heavy Equipment	261,5
Electric	965,0
Fabrication	742,9
Office	1423,9
Cassava Scales	421,8
Cassava Field	44,3

From the results of the exposure time can concluded that the higher the level noise, the shorter the time exposure time. Therefore workers direct exposure is allowed as long as the limit specified time. When workers are exposed to noise from time to time determined, the workers must wear ear protection.

3.3. Cumulative Fraction

Number of cumulative fractions of noise calculated using equation (3). Results noise cumulative fraction calculation presented in the following table.

Table 3. Cumulative fraction calculation result.

Station	Cumulative Fraction
Hopper	0,9
Washing A	5,6
Washing B	5,6
Rasper	9,7
Extractor	5,6
Separator	17,9
Centrifugal	5,6
Oven A	0,9
Oven B	0,9
Bagging A	0,8
Bagging B	0,6
Power Plant A	57,0
Power Plant B	57,0
Coal Boiler	0,055
Diesel	0,098
Heavy Equipment	0,030
Electric	0,0083

Fabrication	0,011
Office	0,0056
Cassava Scales	0,019
Cassava Field	0,181

Based on Table 3, it is obtained 8 points whose cumulative fraction value its noise that exceeds one, no meet the time and quality standards level noise.

3.4. Ordinary Kriging Method interpolation

It has been obtained that the predictive value close to the observation value with RMSE 0,08 and 99% correlation for the model spherical, RMSE 0,09 and correlation 99% for exponential and RMSE models 3,69 and 95% correlation for model gaussian. Based on RMSE and correlation, ordinary kriging method is very good when using the spherical model. Model spherical is used in the ordinary method kriging to get the contour of the distribution noise in this study.

3.5. Inverse Distance Weight Method Interpolation

Power parameters 1, 2, 3, 4 and 5 used in this method. Power selection best based on RMSE and correlation. obtained a predictive value that is close to the value of observation with RMSE 0,78 and 99% correlation for power 5, RMSE 0,005 and 99% correlation for power 2, RMSE 5,56 x 10-5 and correlation 100% for power 3, RMSE 7,61 x 10-7 and 100% correlation for power 4 and RMSE 1,37 x 10-8 and correlation 100% for power 5. Based on RMSE and correlation, inverse method distance weight is very good if using power 5. RMSE is getting smaller and the correlation is getting large with increasing power value. Results This study shows the greater the value of power, then the interpolation result is getting close to the observed value because the RMSE value getting smaller. This result is consistent with research by Pramono [10], that the value of power on the IDW method affect the input points, where the influence will be greater on the points are closer so that the result interpolation is close to the observed value and more detailed contour surfaces. Power 5 used as parameter inverse method distance weight to get contour distribution of noise in this study.

3.6. Evaluation of the Ordinary Kriging Method and Inverse Distance Weight Method

Based on the noise data interpolation, obtained RMSE and correlation of ordinary kriging method and IDW method displayed sequentially in Table 4 and Table 5. Sequentially overall method of IDW generate RMSE and correlation which is better than the method ordinary kriging on noise data. The IDW method that will used to create distribution contours noise level in the research work area.

Table 4. RMSE and Correlation.

Model	Ordinary Kriging	
	RMSE	Correlation
Spherical	0,08	99%
Exponential	0,09	99%
Gaussian	3,69	95%

Table 5. RMSE and Correlation.

Parameter	Inverse Distance Weight	
	RMSE	Correlation
Power 1	0,78	99%
Power 2	0,005	99%
Power 3	$5,56 \times 10^{-5}$	100%
Power 4	$7,61 \times 10^{-7}$	100%
Power 5	$1,37 \times 10^{-8}$	100%

3.7. Equivalent noise distribution mapping

The noise value range is divided into three zone i.e. safe zone, mandatory zone using ear plugs and mandatory zone use ear muffs. Here's the division zone color by level range noise [11].

: < 85 dBA (safe zone)
: 85 dBA – 95 dBA (ear plug mandatory zone)
: **> 95 dBA (ear muff mandatory zone)**

From the results of figure 2 the equivalent noise is dispersed in range from 60 dBA to 105 dBA. Safe zone shown in green with a level 55 dBA to 85 dBA noise is in hopper area, oven A, oven B, bagging A, bagging B, diesel, coal boiler, heavy equipment, electric, fabrication, office, scale cassava and cassava fields. Mandatory zone using ear plugs indicated by color amber with a noise level of 85 dBA up to 95 dBA is in the washing A area, washing B, rasper, extractor and centrifugal. The mandatory zone for using ear muffs is shown red color with 95 noise level dBA to 105 dBA are in the area separator, power plant A and power plant B. The area in the yellow color zone and the red zone noise level has exceeded the threshold value based on the Regulations Minister of Manpower of the Republic of Indonesia Number 5 of 2018 concerning safety and security occupational health, work environment, that is not may exceed 85 dBA for 8 hours per day Noise Source.

Control Companies can apply noise control at source with install acoustic shroud using sound-absorbing material for cover the machine and place the machine on a solid foundation to reduce noise vibration. Suitable acoustic shroud installation applied to production machines. Application of noise control with installing acoustic shrouds or dampers on the machine that generates the source high noise takes a long time long because you have to analyze the work of the machine and machine materials in order to adapted to the material used as a damper. Control of Propagation Media The company has implemented noise control between sources noise with operators in the form of control room as a separator, but on there is no barrier in the production area or control room separator between sound sources with operators. Making control room as a barrier is considered effective to reduce the received noise operator. Making a control room in the form of the room is very suitable to be applied too in the production area where the noise level above 85 dBA. The control room can be reduced exposure to high noise levels received by workers for 8 hours per day.

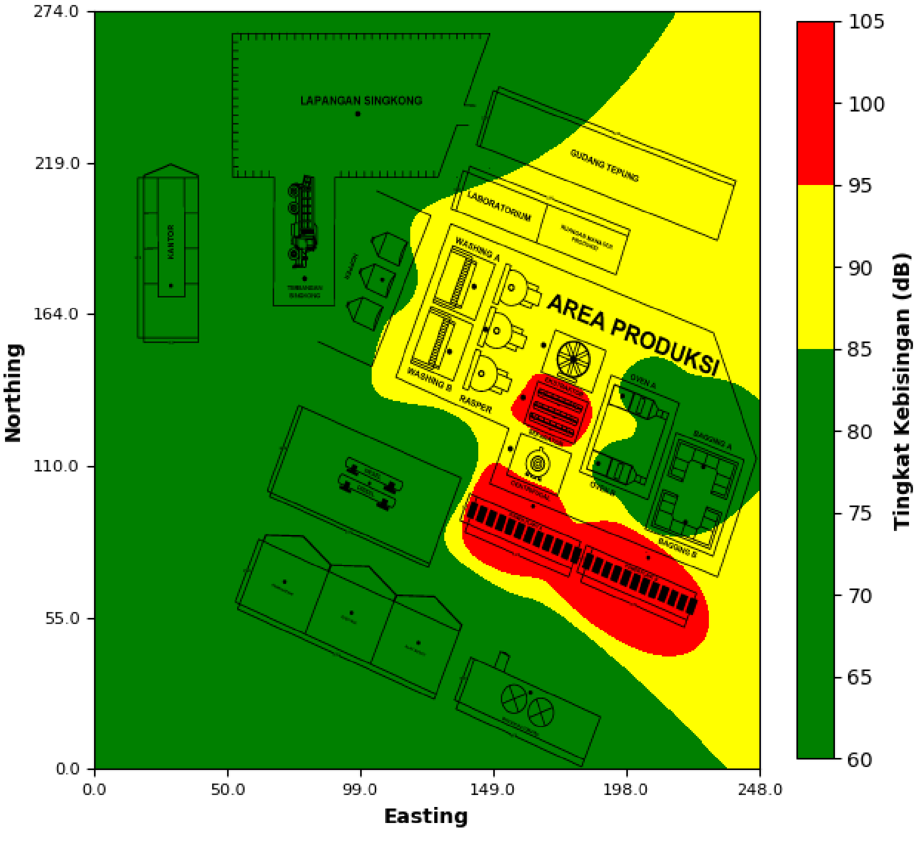

Figure 2. Map of the distribution of noise levels in the work area of PT. SPM II Lampung.

3.8. Noise Source Control

Companies can apply noise control at source with install acoustic shroud using sound-absorbing material for cover the machine and place the machine on a strong foundation to reduce noise vibration. Suitable acoustic shroud installation applied to production machines. Application of noise control with installing acoustic shrouds or dampers on the machine that generates the source high noise takes a long time long because you have to analyze the work of the machine and machine materials in order to adapted to the material used as a damper.

3.9. Propagation Media Control

The company has implemented noise control between sources noise with operators in the form of control room as a separator, but on there is no barrier in the production area or control room separator between sound sources with operators. Making control room as a barrier is considered effective to reduce the received noise operator. Making a control room in the form of the room is very suitable to be applied too in the production area where the noise level above 85 dBA. The control room can be reduced exposure to high noise levels received by workers for 8 hours per day.

3.10. Receiver Control

Administrative

Noise control administrative can be applied by the company to reduce noise exposure time by rotating worker time based on fraction calculation. Based on Table 2 There are 8 location points whose fraction values are exceeds one. To generate fractions less than one worker who is at more than one fraction point must be subtracted noise exposure time and moved in areas where the noise level is higher low until the fraction value is less than one.

Personal Protective Equipment

Use of ear plugs with NRR 30 dBA can be used to maximum level noise 96 dBA, namely washing area A. Use of ear muffs with NRR 40 dBA can be used to maximum level noise 101 dBA. Workers who are in 85 dBA noise area up to 96 dBA required ear plug, area with a noise level of 96 dBA to 101 dBA required wearing ear muff and area whose noise level is more than 101 dBA (power plant) must use tools dual ear protection (ear plug and ear muffs). The company has implemented use of ear plugs or ear muffs in the area production and power plants, but workers there are still many in the production area who have not worn ear plugs or ear muffs, so that there is a need for strict sanctions from the management in an area where the noise level exceeds the threshold value if still find workers who don't wear ear.

IV. CONCLUSION

The interpolation results have obtained RMSE 0,08 with 99% correlation for method best ordinary kriging and RMSE 1,37 x 10^{-8} with 100% correlation for the best inverse distance weight method. Inverse method weight distance is rated better and details in the contours of the distribution in the work area of PT. Sinar Pematang Mulia II Lampung. Control Solution by rotating the noise exposure time on a scale until the cumulative fraction is less than one. Technically, by installing an acoustic shroud on a machine with a high noise level, creating a control room in the form of a production area and requiring ear plugs with an NRR of 30 dBA and ear muffs with an NRR of 40 dBA.

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